D. & R. G. W. Completes the

Signaling of Its Main Line

Five-year program includes 722 miles of automatic block signals and two C. T. C. installations. Excellent performance report—Five-year records on a-c. floating system show operating cost for electric current to be 85 cents per mile per month

By B. W. Molis

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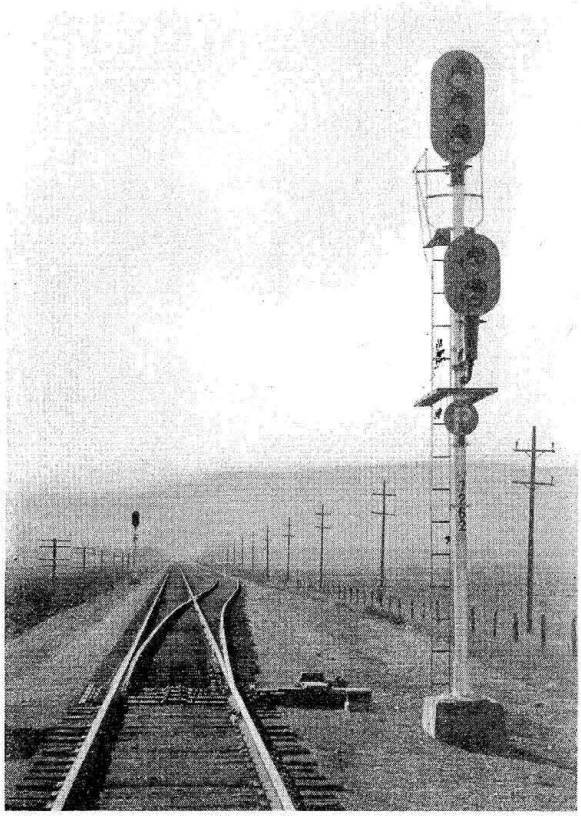
THE year 1931 marked the completion of an extensive five-year signal construction program on the Denver & Rio Grande Western. Automatic signals were unknown on this railroad previous to 1927, when a signal department was organized and 104 miles of single track was equipped with automatic block signals. The program was continued with 126 miles of single- and 44 miles of double-track signaling the following year, and 233 miles of single- and 5 miles of double-track signaling in 1929. Centralized traffic control was installed through the Tennessee Pass tunnel in 1928 and the same type of equipment was provided on 32 miles of single-track between Provo, Utah, and Midvale in 1929. The automatic signaling construction was continued with the installation of 50 miles of double-track between Soldier Summit, Utah, and Provo, in 1930, and between Pueblo, Colo., and Swallows, in 1931, which marked the completion of automatic block signaling on 721.9 miles of line involving 925 color-light signals. Forty-two highway and street crossings have been protected by the standard flashing-light crossing signals. Two automatic interlockings at railroad crossings were included in the program.

The D. & R. G. W. signaling is of interest, not only because it was installed on such a rapid schedule, but also for several other reasons. For example, the signaling equipment is all of one design and manufacture, having been furnished by the General Railway Signal Company, and, with the exception of the 1930 and 1931 program, was installed by the signal company's forces. This uniformity of equipment and construction details has simplified maintenance work and reduced the stock necessary for replacement and repairs. The a-c. floating system of power was used throughout these installations, and, as some of the signaling has now been in service for nearly five years, some interesting data are available as to the cost of operation of such a system of power supply.



Typical passing-track layout in centralized control territory

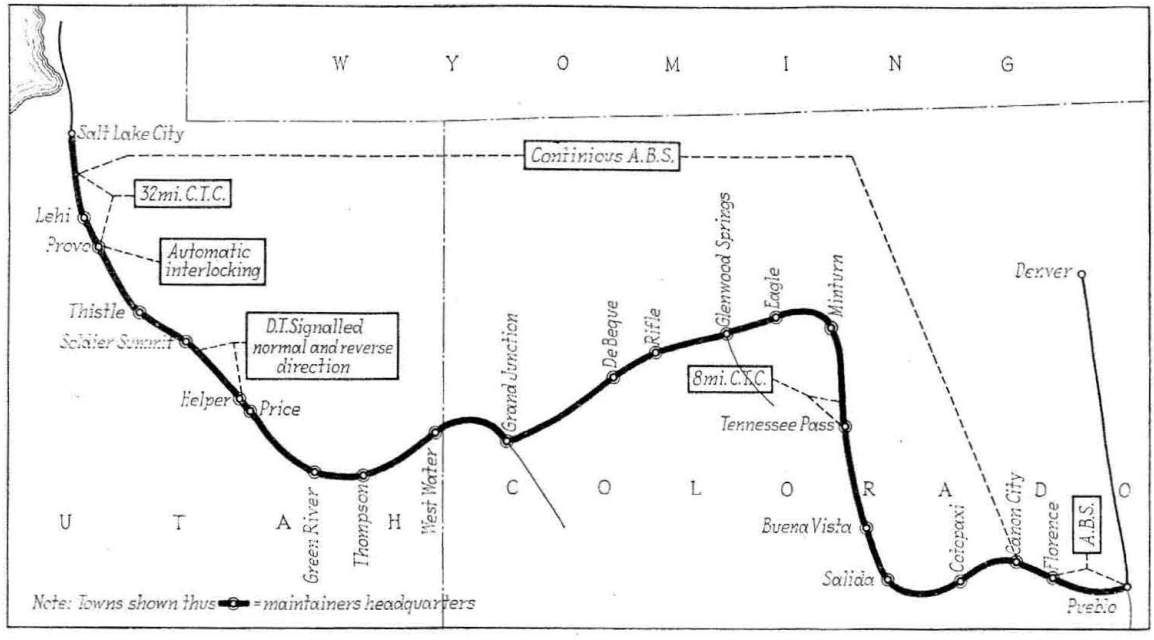
In 1925 the D. & R. G. W. decided to rehabilitate the main line so that heavy through traffic could be handled on a faster schedule. One of the major items of the improvement program was to provide automatic block signals on the entire main line, in order to increase the safety of train operation, especially in mountainous territory, as well as to expedite train movements and eliminate delays. To start with, certain sections of the line were reconstructed to eliminate some of the sharper curves; and new rail, ties, and ballast were provided throughout. Existing passing tracks were lengthened to hold 100 to 120 cars, and new passing tracks were added wherever required. These track and signal improvements increased the gross ton miles per freight-train hour on the main line from 22,774 in 1925 to 34,934 in 1931.

Why the Signals Were Installed

The track improvements were completed first on the Grand Junction division and the first signaling was installed in this territory during 1927, between Gypsum and Palisade, 104 miles of single-track. This section of line is in typical mountainous territory, the maximum grade being 1.42 per cent. This single track was very busy

at that time, the average number of train movements each 24 hours being about 46, as indicated by a plotted chart. It was thought that from the standpoint of safety and operation, the greatest benefit could be derived by equipping this portion of the line with signals first and later extending them to other sections as fast as practicable.

The 1928 program included several sections of signaling, all in mountainous territory. For example, the section of single-track between Canon City and Minturn system included not only the signals for directing train movements but also power-operated switches for six passing tracks and spring switches at the two ends of double track. This system has proved to be entirely satisfactory, all trains being handled safely and without delay, the average time saving being over one minute per mile on all freight trains. A detailed description of this installation was published on page 48 of *Railway Signaling* for February, 1930.



Map of D. & R. G. W. showing territory equipped with signaling

extends through the famous Royal Gorge of the Arkansas river, up the eastern slope of the Continental Divide and through the tunnel at Tennessee Pass. The double track from the west and of Tennessee Pass tunnel, down to Minturn, 18.7 miles of 3 per cent grade, was also equipped with signals as a part of this installation. Centralized traffic control was installed for directing train movements in the vicinity of Tennessee Pass, the installation including power-operated switches for several passing tracks, and spring switches for the ends of double track. The operation has been exceptional in spite of the elements prevailing at an elevation of 10,242 ft. Also, as a part of the 1928 program, signals governing train movements for both normal- and reverse-direction running were installed on 10 miles of double track on the eastern slope of the Wasatch mountains in Utah, between Maxwell and Soldier Summit.

The 1929 construction included the largest program of all. Signals were installed on 183.9 miles of single-track from Palisade, Col., across the desert to Maxwell, Utah. Another short installation, from Swallows, Col., to Florence, involved 17.1 miles of single- and 2.2 miles of double-track. Perhaps the most important feature of this 1929 program was the installation of centralized traffic control on 32 miles of single track between Provo, Utah, and Midvale. A section of 11 miles of double track extends from Salt Lake to Midvale with 32 miles of single track from there to Provo, while double track extends from Provo up over the Wasatch mountains and down to Helper. This Provo-Midvale section of single track was therefore a bottle neck, handling from 24 to 50 trains daily. No heavy grades were involved on this section of the line, the maximum being 0.65 per cent and no excessive curvature is encountered. The C. T. C.

In 1930 automatic signals were installed on 50 miles of double track between Soldier Summit, Utah, and Provo. In 1931, 12 miles of double track between Pueblo, Colo., and Swallows was signaled, thus completing the automatic signaling with the exception of nine miles of double-track main line from Pueblo, Colo., to Midvale, Utah. The line from Pueblo to Denver is operated jointly with the Santa Fe, each road owning a single-track line between these points, trains being operated northward on the D. & R. G. W. and southward on the Santa Fe, with manual block protection.

Special Control Features

All of the signals are the G. R. S. Type-D color-light type. The single-track control circuits are the regular absolute permissive block type, and the power is supplied by the a-c. floating system, using a 550-volt power supply line. To preclude interruptions or "winking lights" due to the high-speed, light-engine movements prevalent in the mountainous territory, thermal relays are used. The thermal relay is so arranged that, after the circuit is closed, a time interval elapses before the control relay picks up. On account of the adverse mountain grades encountered, grade signals were installed, the circuits for which are so arranged that the grade-signal indication is displayed only for following movements.

Positive Signals Are Normally Lighted

All of the positive signals and other signals in yard limits are normally a-c. lighted, but in case of a power outage these lights are switched to the battery supply and become approach lighted. All other signals are lighted only upon the approach of trains, excepting when in-

dicating Stop. The Stop indication lamp is continuously lighted when the signal is in the Stop position. These features, together with the back-light on the red unit, are for the convenience of track forces.

In spite of the extreme curvature of the line, close proximity of canyon walls and other obstructions, it was possible, by using deflecting lenses, to secure a visible range of at least 1,000 ft. for each signal. The signal units use 10-volt, 10-watt, bayonet-base, rebased lamps.

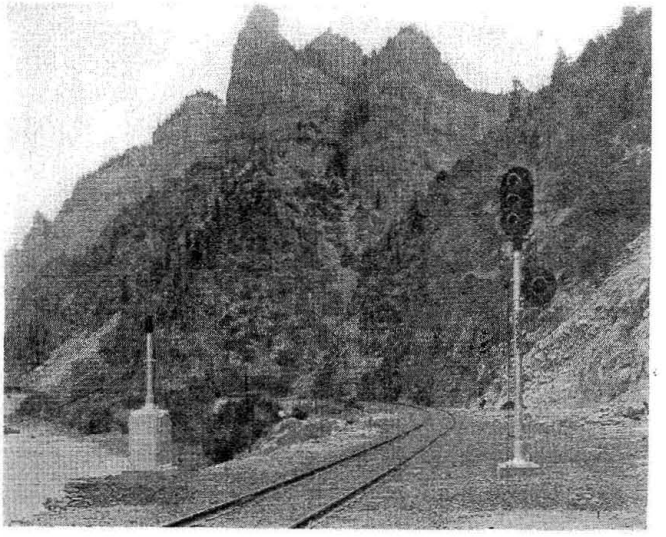
Summary of Causes of Signal Interruptions

Creditable	*Cases*	*Trains Detained*
Broken rails	33	64
Switch points open ¼ in. or more	13	13
Train in block	1	1
Washout	1	1
Unavoidable		
Bulb burned out	4	4
Broken wires	17	29
High-resistance relay contacts	7	9
Malicious tampering	2	2
Broken parts	1	1
Lightning interference	5	8
Insulated jts	1	2
Snow on lens	22	22
Wet track	4	8
Avoidable "A"		
Adjustments	10	13
Joint not bonded	1	2
Broken wires	2	3
Avoidable "B"		
Broken bond wires	2	3
Wet track ballast in contact with rail	4	7
Bridge gangs	1	1
Non-insulated push car	1	1
Avoidable "C"		
Unsoldered batt. jumper	1	2
Defective cam in switch box	1	1
Relays	2	3
Unknown		
No cause found	2	2
Total	138	202
False Signal Indications		None
Signal Movements Per "A" and "B" Interruption		271508
Signal Movements Per Creditable Interruption		118785

Large Cases for Relays and Batteries

Large sheet-metal cases house the relays, rectifiers and storage batteries. These cases are all located on the pole-line side of the track, no relay control wires being run underground, and the light control wires for signals on the opposite side of the track are in underground armored parkway cable.

The relays are all of the wall type, mounted on spring suspensions to eliminate the effect of vibration. The terminals and arresters are mounted on a board at the bottom of the case, as shown in the view, and the No. 12 Pullman special flexible insulated jumpers from these terminals run up the sides of the case and across to the relays in cables neatly laced and held to the wall by leather straps. The wires are tagged at the terminal or arrester and also on the jumper at the relay. This type of construction permits ready inspection and testing of all equipment. The Balkite and dryplate rectifiers and the storage battery are housed in the opposite half of the case, a door being provided on each side. Exide Type-KXHS-7 and KXHS-9 storage cells are used throughout, four cells being used for the signals and line circuits and one cell for each track circuit. Fourteen cells are used on power switch machines and five cells are used on highway-crossing signals.



Signals insure safety in mountainous country on the D. & R. G. W.

The track relays are 4-ohm, the track circuits averaging 3,200 ft., with a maximum of 4,000 ft. The rails are bonded with two 46-in. No. 8 galvanized iron bond wires using duplex channel pins. On account of the numerous curves, the rail wear is excessive in this territory and therefore this type of bonding was considered as having a life equal to that of the rail and more expensive bonding was not justified. However Ohio-Brass steel-strand welded bonds are used in all tunnels and on numerous other track circuits.

On the early installations, rail connections were made

A. B. S. Interruptions on the Grand Junction Division in 1931

Month	Creditable Cases	Creditable Trains Detained	Unavoidable Cases	Unavoidable Trains Detained	Avoidable "A" Cases	Avoidable "A" Trains Detained	Avoidable "B" Cases	Avoidable "B" Trains Detained	Avoidable "C" Cases	Avoidable "C" Trains Detained	Unknown Cases	Unknown Trains Detained	Total Signal Mvmts.	Signals in Service
Jan.	1	2	2	4	..	..	..	..	1	2	..	..	436613	585
Feb.	5	9	1	2	..	..	1	1	..	..	..	..	384040	585
March	2	4	24	24	..	..	..	..	..	..	..	..	439854	585
April	5	9	2	3	..	..	3	5	1	1	1	1	430262	585
May	3	4	2	2	..	..	2	3	..	..	1	1	489108	585
June	1	1	7	12	..	..	1	1	..	..	..	..	419161	585
July	2	4	2	2	1	2	1	2	..	..	..	..	509268	585
Aug.	10	16	5	7	..	..	..	..	..	..	..	..	524854	585
Sept.	4	4	9	14	1	1	..	..	..	..	..	..	547507	585
Oct.	7	13	4	7	2	2	..	..	1	1	..	..	618954	585
Nov.	5	8	2	3	4	8	..	..	..	..	..	..	488048	585
Dec.	3	5	3	5	5	5	..	..	1	2	..	..	414008	585
Totals	48	79	63	85	13	18	8	12	4	6	2	2	5701677	585

with No. 9 solid-copper wire with 5/64-in. Kerite insulation, in redwood trunking. On later installations trunking was eliminated and a special Kerite underground finish cable was used.

Features of A-C. Floating System

The a-c. floating system is used as a power supply for both the signals and the track circuits. Alternating current was available at numerous points and the longest supply circuit is 33 miles. The cost of all power for the installation averages 1¾ cents per kw-h. A 550-volt supply circuit is carried on No. 4 and No. 6 copper weather-proof line wire placed on the field side of the new 10-pin crossarm on the existing Western Union pole line which was reconstructed. The line wire for the control circuits is No. 10 hard-drawn copper with weather-proof insulation. Ohio-Brass No. 9404 porcelain insulators are used for the 550-volt a-c. circuit and glass insulators on the 10-volt d-c. control circuits.

At tunnels and along the canyons, the pole line is, at some places, 1,500 ft. from the track, which increased the difficulty of stringing the line wires and required the use of stub pole lines to the signals. At each signal or cut-section location the taps from the 550-volt line are taken to two General-Electric porcelain plug fuse cut-outs and then to a 550/110-volt air-cooled transformer. This transformer is protected by two G. E. compression-type arresters, also mounted on the crossarm. The 110-volt circuit is taken to the relay case and, after going through a set of 10 amp. fuses, connects with the low-voltage transformer.

The Signal Department Organization

In addition to the signal engineer and assistant signal engineer, the signal department organization of the D. & R. G. W. cosists of 21 maintainers, located as indicated on the map. On straight automatic-block-signal single-track territory each maintainer has about 40 miles, involving about 50 signals.

Two men handle the C. T. C. territory from Midvale to Provo, which also includes the automatic interlocking at Lakota. None of the maintainers has a helper, except the one at Pueblo, Colo., whose territory involves outlying signals and interlockings. Each maintainer is provided with a motor car, the Buda 419 or 519 type being practically standard.

A-C. Floating System Satisfactory

The a-c. floating system has proved to be very economical in block-signal operation. To date we have not experienced any battery replacement of any nature. The power charges incidental to the a-c. floating system have averaged 85 cents a month per mile.

Signal Maintainers' Territories

Headquarters	Track Miles Maintained S.T.	D.T.	Auto. Signal Units	Xing Signal Units	Int. & C.T.C. Units	Spring S. Units	Miscl. Units	Total A.R.A. Units
Pueblo	.....	95.1	318	208	410	12	4	953
Cannon City	26.71	20.72	490	52	75	18	39	674
Cotopaxi	32.00	.....	419	7	...	...	39	465
Salida	28.54	3.72	411	10	...	18	21	...
	1.00	.....	...	9	...	...	...	469
Buena Vista	33.80	.....	510	7	...	...	15	532
Tenn. Pass	17.17	7.66	373	...	35	18	17	443
Minturn	6.21	28.38	372	17	...	24	15	428
Eagle	32.00	.....	454	3	...	...	34	491
Glenwood	28.20	.....	438	...	...	...	27	465
Rifle	35.80	.....	497	10	...	...	37	544
De Beque	33.60	.....	494	10	...	...	29	533
Grand Jct.	34.20	.....	497	12	...	6	39	544
Westwater	39.60	.....	391	...	...	...	22	413
Thompson	39.00	.....	451	...	...	...	25	476
Green River	35.40	.....	336	...	...	...	27	373
Price	35.80	.....	424	7	...	...	32	463
Helper	3.61	27.58	551	7	...	36	22	616
Soldier Summit	.....	44.80	359	...	...	12	14	385
Thistle	.....	53.60	425	...	...	18	16	459
Provo	2.00	.....	...	...	23	...	...	...
	10.93	27.74	460	36	44	6	24	593
Lehi	1.00	.....	13	...	...	...	...	...
	26.24	22.60	422	100	157	12	23	727
Total	680.45	331.92	9,105	495	744	180	522	11,046

Denver, Colorado, April 1, 1932.

As an example details are given of the cost of the maintenance and operation of the A. B. S. on the Salt Lake division, which comprises 192 track miles, all of which is double track, with the exception of 32 miles.

1931 Charges for A. B. S. on Salt Lake Division

Item and Account	Total Cost 1931	Average Monthly Cost	Annual Cost per Mile (192 Miles)	Annual Cost per Unit (2448 Units)
404 Labor	$3765.74	$313.81	$19.62	$ 1.53
404 Material	521.50	43.45	2.71	.21
404 Power	1984.54	165.38	10.34	.81
404 Total	6271.78	522.64	32.67	2.56
249 Labor	4630.31	385.85	24.12	1.89
249 Material	4138.79	344.89	21.56	1.69
249 Total	8769.10	730.75	45.68	3.58
220 Spring switches	291.94	24.32	1.52	e20.85
220 Other track	1125.31	93.77	5.86	.46
225-405 Labor, matl. power	599.40	50.00	3.12	e35.25
247 Telephones & Lines	303.88	25.32	1.58	e5.23
269 Gas, oil, repairs & labr.	715.71	59.62	3.72	ex143.14
Miscell.	259.76	21.65	1.35	.106
Total Charges	18336.88	1528.07	95.50	*6.665

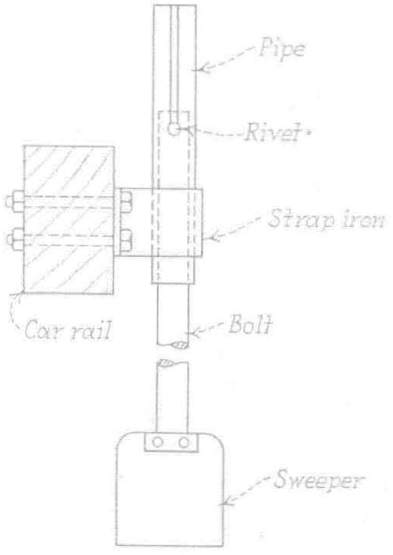
*2751 A.R.A. units total. x 5 cars. e Each.

Eighteen miles of the double track is signaled for normal and reverse direction. Five signal maintainers are assigned to this division and the apparatus includes 229 automatic block signals, 17 highway crossing signals, 32 miles of C. T. C. with 12 power switches, one automatic

(Continued on page 156)

The following material is required: Two pieces of ½-in. pipe 9 in. long, two ⅝-in. bolts about 11 in. long (cross-arm bolts are entirely suitable), two pieces of belting 4 or more inches wide by 3 in. long, one piece of strap iron about 1½ in. by ¼ in., a rivet and some bolts.

A slot ¼ in. wide and 6 in. long is cut in one side of the pipe, and a slot of the same width but only ½ in. deep is cut in the opposite side. The heads of the bolts are flattened and two ¼-in. holes are drilled through them. The pieces of belting are bolted through these holes. Another ¼-in. hole is drilled through the bolt about ½ in. from the opposite end and slightly counter-



Sketch of rail sweep assembly

sunk on one side. The bolt is then put through the pipe; the rivet is pushed through the hole in the pipe until the end just protrudes on the countersunk side. The rivet is then headed. The strap iron is bolted to the car railing and the pipe is suspended therefrom. The pipe may be fastened to the strap iron or the strap may be bent around the pipe, being careful to have a good tight fit. The sweeper is not set at right angles to the rail, but at an angle of about 15 deg., thus making it sweep better and ride over joints more smoothly.

When the sweep is being used, the rivet is in the long slot in which it works up and down easily, and which prevents the sweeper from turning. When it is desired to raise the sweeper, the rivet is raised above the end of the pipe, is given a half turn and is let down in the short slot.

Lorne H. Sipperley, assistant signal maintainer, Michigan Central, suggests the following in connection with alining color-light signals: "On this road, it has been the practice for one man to adjust the signal while the other stays on the ground at a point to which the light is to be focused. When the sun is shining on the roundels, it is very difficult for the man on the ground to see the light, but if he will wear a pair of smoked glasses, he will have no difficulty."

A. T. Alexis, signal maintainer on the Buffalo, Rochester & Pittsburgh, at Johnsonburg, Pa., suggests the use of drag-type contacts on semaphore signal circuit controllers, to minimize trouble due to the formation of frost on the controllers. The correspondent states that he has never had a failure caused by frost forming on a drag-type contact.

D. & R. G. W. Signaling

(Continued from page 144)

interlocking, 14 spring switches, 58 telephones, or a total of 2,751 A. R. A. units, 2,448 of which are I. C. C. accounts No. 249 and No. 404. Charges for labor, material and power for the Salt Lake division for the year 1931

Summary of Performance for Entire Road

Year	Total Signal Movements	Avoidable Interruptions	Average Signal Movement per Interruption	False Clear Signals	Movement per False Clear Signal
1927	967,108	10	96,710	0	967,108
1928	3,549,994	24	147,916	0	3,549,994
1929	7,980,772	52	153,476	2	3,990,386
1930	10,039,411	66	152,113	0	10,039,411
1931	9,109,413	53	171,875	0	9,109,413
Total Five Years	31,646,698	205		2	
Avg. For Five Years			154,374	2	15,823,349

with yearly and monthly averages divided between various I. C. C. accounts, and average costs per mile and per A. R. A. unit are shown.

The charges include labor and material incidental to 10 miles of rail renewal. Another statement shows a comparison in regard to signal movements and some averages that give a good example of performance.

Explanation of Classification of Interruptions

CREDITABLE INTERRUPTION

An interruption due to those conditions which the signals were installed to detect,—such as, train in the block, open switch, broken rail, etc.

AVOIDABLE INTERRUPTION

Avoidable "A"—(A) An interruption due to improper inspection or maintenance, or lack of either, on the part of signal maintainer. An interruption caused by track, line or other conditions which could have been prevented by the maintainer had he notified the proper authority in time for corrective action to have been taken,—such as, ballast in contact with rails or unloaded between rails, improper drainage, defective insulated joints, switch rods or gage plates, etc.

(A2) An interruption due to improper handling, inspection or lack of either on the part of the construction foreman.

Avoidable "B"—(B1) An interruption due to a condition of track brought about by employees beyond the control of signal supervisor,—such as, adjusting switch without co-operation of signal maintainer, improper tamping of ties under a rail joint thereby causing the bond wires to break, allowing ballast in contact with rails, improper drainage, not acting upon request by maintainer for renewal of insulations, etc.

(B2) An interruption due to conditions, exclusive of track, brought about by employees beyond control of a signal supervisor,—such as, linemen interfering with signal wires, etc.

Avoidable "C"—An interruption due to faulty design or defective material, which, by proper inspection would not be apparent,—such as, defective wire joints in trunking or conduit in good condition but inaccessible to inspection, flaws in castings, etc.

UNAVOIDABLE INTERRUPTION

An interruption due to conditions beyond the reasonable control of railway employees,—such as, lightning, flooding of track, washout, dragging equipment, derailment, etc. when same does not render the track or block unsafe for the movement of trains.

INTERRUPTION ACCOUNT OF UNKNOWN CAUSES

An interruption which, upon investigation, develops signal as operating correctly and for which a thorough inspection fails to disclose a cause.